

**COMPARATIVE COMPUTED TOMOGRAPHIC ANALYSIS OF
EFFICACY OF HAND INSTRUMENT AND DIFFERENT
ROTARY INSTRUMENTS TO REMOVE GUTTA-PERCHA
FROM ROOT CANALS-AN IN VITRO STUDY**

*A Dissertation submitted
in partial fulfillment of the requirements
for the degree of*

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BRANCH – IV

CONSERVATIVE DENTISTRY AND ENDODONTICS



THE TAMILNADU DR. MGR MEDICAL UNIVERSITY

CHENNAI – 600 032

2013 – 2016

DECLARATION BY THE CANDIDATE



I hereby declare that this dissertation titled **“COMPARATIVE COMPUTED TOMOGRAPHIC ANALYSIS OF EFFICACY OF HAND INSTRUMENT AND DIFFERENT ROTARY INSTRUMENTS TO REMOVE GUTTA-PERCHA FROM ROOT CANALS-AN IN VITRO STUDY”** is a bonafide and genuine research work carried out by me under the guidance of **Dr.K.AMUDHALAKSHMI, Associate Professor, Department Of Conservative Dentistry and Endodontics, Tamil Nadu Government Dental College and Hospital, Chennai-600003.**

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DECLARATION

TITLE OF DISSERTATION	“COMPARATIVE COMPUTED TOMOGRAPHIC ANALYSIS OF EFFICACY OF HAND INSTRUMENT AND DIFFERENT ROTARY INSTRUMENTS TO REMOVE GUTTA-PERCHA FROM ROOT CANALS-AN IN VITRO STUDY”
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And

MRS. DR. K.AMUDHALAKSHMI M.D.S aged 46 years working as Associate Professor in Department of Conservative Dentistry & Endodontics at the college, having residence address at AE 86-7th street, Tenth Main Road, Anna Nagar, Chennai – 40 (‘herein after referred to as the Principal Investigator’)

And

MR.DR.AJAY F aged 38 years currently studying as **Post Graduate student** in Department of Conservative Dentistry & Endodontics, Tamil Nadu Government Dental College and Hospital, Chennai 3 (herein after referred to as the PG student and coinvestigator’).

Whereas the PG student as part of her curriculum undertakes to research on **“COMPARATIVE COMPUTED TOMOGRAPHIC ANALYSIS OF EFFICACY OF HAND INSTRUMENT AND DIFFERENT ROTARY INSTRUMENTS TO REMOVE GUTTA-PERCHA FROM ROOT CANALS-AN IN VITRO STUDY”** for which purpose the Principal Investigator shall act as principal investigator and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG student as to the extent possible as a Co-investigator.

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In witness where of the parties herein above mentioned have on this day, month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its **Principal**

PG Student

Witnesses

Student Guide

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ABBREVIATIONS

EDTA	Ethylene diamine Tetraacetic acid
NiTi	Nickel titanium
CT	Computed Tomography
GP	Gutta-percha
ProTaper R	ProTaper retreatment file
Mtwo R	Mtwo retreatment file

ABSTRACT

Aim

To determine the efficiency of rotary NiTi instrumentation with ProTaper retreatment file, Mtwo retreatment file, DRaCe retreatment file and, hand instrument with Hedstrom file without a solvent

Methodology

Forty straight single rooted premolars were prepared with ProTaper Universal instruments up to F3 size and root canals were obturated with a F3 ProTaper gutta-Percha points and a epoxy resin based sealer by using the single cone technique. The samples with the obturation material were divided in to four groups each containing 10 samples for volume analysis using Spiral CT. Group 1 retreated with ProTaper retreatment file, Group II retreated with Mtwo retreatment file, Group III retreated with DRaCe retreatment file and group IV retreated with Hedstrom file without solvent. A second Spiral CT was done for all the specimens and the volume of remaining material in each root canal was estimated by three dimensional volume rendering software to calculate the removal efficiency. Data were analyzed statistically.

Results

D RaCe group had the highest mean removal efficiency followed by M two R, Pro Taper R. Least mean removal efficiency was observed among Hedstrom file. Group III \geq Group II \geq Group I $>$ Group IV. However this difference was not found to be statistically significant ($p=0.06$). Lowest mean time taken for retreatment was by DRaCe Group followed by Mtwo and ProTaper while highest mean total time for retreatment was observed with Hedstrom file.

Conclusions

All root canals had residual filling material after retreatment. Additional instrumentation is required to enhance cleaning efficiency during retreatment. Gutta-percha with epoxy resin based sealer can be removed from canal without solvent by rotary NiTi file and removal with Hedstrom file is tedious and time consuming.

Keywords: Retreatment, Nickel Titanium rotary retreatment file, Computed Tomography , ProTaper retreatment file, Mtwo retreatment file, DRaCe retreatment file.

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INTRODUCTION

Persistent or secondary intra radicular infection is a major cause of post treatment disease. Various cause of treatment failure includes poor aseptic technique, missed canal, inability to prepare the canal to the length, procedural error, poor obturation, poor restoration and coronal microleakage and resistant bacteria. Therefore, nonsurgical root canal retreatment is indicated when the initial procedure has failed and can be corrected by improving root canal disinfection and debridement, and placing a permanent and homogeneous filling.

Non surgical endodontic retreatment is the treatment of choice for endodontic failure. It replaced apical surgery in case of treatment failure. Recognition of persistent infection in root canal space is the main cause of such failure. Persistent apical periodontitis caused mainly by microorganism viable in primary root canal treatment. Cleaning and disinfection of entire root canal system is required to remove the infection. To facilitate complete disinfection of canal complete removal of obturating material and access to apical foramen should be regained. So that irrigating solution and intracanal medicament can contact with root canal wall. But it provides greatest clinical difficulties.

Safe, successful and effective removal of root filling materials is an integral component of non-surgical root canal retreatment. Gutta-percha is the most widely used and accepted root filling material. Gutta-percha is usually used as a core filling material in combination with a sealer. Therefore in the majority of retreatment cases the most commonly encountered root filling material is likely to be gutta-percha. Removal of gutta-percha can be accomplished with hand instruments, heat carrying instruments, solvents, ultrasonic system, laser system and rotary nickel titanium

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instruments like ProTaper retreatment file, Mtwo retreatment file, DRaCe retreatment file, reciprocating NiTi system R Endo, Self adjusting file.

Retreatment is more time-consuming compared with initial root canal treatment. More efficient and more rapid techniques for removal of root filling materials would be an advantage.

Use of nickel titanium instrument system used for removal of obturating material is efficient and possibility of removing gutta-percha without solvents. Use of solvent can form a thin film of gutta-percha on the wall of root canal and it can reduce the action of intra canal medicament and root canal sealer⁴³. Rotary instruments can be used without solvents. It also have the advantage of elimination of apical extrusion of gutta-percha by excessive dissolution and non utilisation of potential harmful solvent¹³. So in this study retreatment procedures are carried out without solvents to evaluate the efficiency of NiTi rotary retreatment files and Hedstrom file.

Various nickel titanium (NiTi) rotary endodontic instruments have been developed to facilitate cleaning and shaping of root canals. To improve safety for preparation and to prepare more appropriate shapes, new instrument designs with noncutting tips, radial lands, varying tapers and rake angles, and changing pitch lengths have been developed. The ProTaper Universal retreatment system comprises three retreatment files, D1, D2 and D3 one for each third of the root canal. These instruments have a convex triangular cross section. D1 have an active working tip to facilitate initial penetration of the filling material. Non active tips of D2 and D3 reduce the incidence of ledging, perforation, and stripping during the removal of filling materials.⁵⁶

INTRODUCTION

ProTaper Universal retreatment system is able to remove large amounts of gutta-percha through spirals running around the instruments, which produce both cutting and softening actions. The negative cutting angle and the absence of radial land exert a cutting action as opposed to a planning action on the gutta-percha.¹⁷

Mtwo retreatment file consists of two instruments with Mtwo R1 and Mtwo R2. Both instruments have an S shaped cross section as do the files of basic sequence but they have a shorter pitch length to enhance advancement of the file in to the filling material. Mtwo retreatment has active tip for all retreatment instruments Mtwo R25/.05 and Mtwo R15/.05.⁵³

D-RaCe Retreatment files have been introduced recently. These retreatment instruments, DR1 and DR2, were designed with alternating cutting edges as well as a triangular cross section. DR1, have an active working tip to facilitate initial penetration of the filling material. Very limited studies are there to compare the efficiency of newer retreatment file without solvent and there are limited study that compare the efficiency of ProTaper retreatment file, DRaCe retreatment file, Mtwo retreatment file and hand instrument Hedstrom file without solvent to remove gutta-percha with epoxy resin sealer (AH plus) up to our knowledge .So these instruments are selected for this study.

The evaluation of gutta-percha removal has been performed by radiographic assessment, rendering teeth transparent, longitudinal sectioning prior to photographic microscopic analysis, Operative microscope, Scanning Elecron Microscope, clearing techniques, stereomicroscopy, Computed Tomographic analysis and micro CT.²²

INTRODUCTION

Computed Tomography (CT) has been used in in this study because it enables 3-dimensional evaluation of the root canal system before and after instrumentation. It has the advantage of less invasive method for quantitative assessment of removal of filling material and it avoids the displacement of filling material during cleavage.^{4,30,32,61}

The aim of the study is to compare the efficacy of hand instrument-Hedstrom file and different new NiTi rotary retreatment systems - ProTaper retreatment file, Mtwo retreatment file, DRaCe retreatment file to remove gutta-percha and epoxy resin based sealer (AHplus) from root canal without solvent using Computed Tomographic analysis.

AIM AND OBJECTIVES

AIM

To Compare the efficacy of hand instrument and different rotary instruments to remove gutta-percha from root canals by Computed Tomographic analysis.

OBJECTIVES

1. To determine the efficiency of hand instrument with Hedstrom file, rotary instrumentation with ProTaper retreatment file, Mtwo retreatment file, DRaCe retreatment files without a solvent
2. To determine the volume of filling material before and after retreatment using Multislice Spiral CT
3. To evaluate the total time for retrieval by using a stop watch

REVIEW OF LITERATURE

RETREATMENT

Bergenholtz G et al⁴ (1979) carried out in vivo study in a 660 previously root filled tooth with endodontic failure following a 2-year observation. He concluded that Seventy-eight percent of the cases with pathologic lesion present periapically prior to retreatment either completely healed or displayed an obvious size-reduction of the process. Retreatments carried out because of technical inadequacies alone were successful in 94% of the cases. It was concluded that endodontic retreatment whenever possible is the method of choice when treating defective endodontic fillings complicated with pathologic processes periapically

Wilcox LR et al⁵⁹ (1987) studied endodontic retreatment and evaluation of gutta-percha and sealer removal. He uses heated hand plugger, chloroform solvent, and reinstrumented with kflex file. He concluded that all methods of removal left debris in the canals. Sealer accounted for the greatest percentage of debris in canals.

Jeng,HW et al²³ (1987) studied the removal of hard paste fillings from the root canal by ultrasonic instrumentation and concluded that this technique was found to be safe and effective. It allowed the retreatment of the involved teeth without the need for surgical intervention.

Stamos DE et al⁴⁹ (1988) in his study on retreatodontics and ultrasonics stated that ultrasound can simplify retreatment in endodontic failures.

Torabinejad M et al⁵⁶ (2009) studied outcomes of nonsurgical retreatment and endodontic surgery by a systematic review concluded that nonsurgical retreatment shows improved outcomes with increasing recall time. These findings suggest

REVIEW OF LITERATURE

nonsurgical retreatment offers a more favorable long-term outcome and should be considered as a primary treatment approach when possible compared with endodontic surgery.

Roggendorf MJ et al³⁹ (2010) stated that residual sealer may act as shelter for bacteria, particularly in the apical canal level where it is the most abundant. In this study he concluded that retreatment of the canal to two sizes beyond the prefilling size is warranted to eliminate most of the residue in the apical level of the canal.

Zuolo et al⁶⁴ (2013) compared the efficacy of reciprocating and rotary techniques with that of hand files for removing gutta-percha and sealer from root canals concluded that the reciprocating technique was the most rapid method for removing gutta-percha and sealer followed by the rotary technique and hand file technique.

Pawar SS et al³³ (2014) stated AH plus as an epoxy resin-based sealer has greater adhesion to root dentin. AH Plus has better penetration in to the micro-irregularities because of its creep capacity and long setting time which increases the mechanical inter locking between sealer and root dentin. But there is inadequate bonding between the sealer and the gutta-percha point allowing fluid leakage at this interface.

Kim H et al²⁵ (2015) compared the retreatment efficacy of calcium silicate and epoxy resin-based sealers and residual sealer in dentinal tubules and noted that AH plus sealer penetrated slightly deeper into the dentin than the bioceramic sealer and concluded that there was no significant difference in retrievability between the AH Plus sealer group and the bioceramic sealer

REVIEW OF LITERATURE

Silva RV et al⁴⁵ (2015) studied the filling effectiveness and dentinal penetration of endodontic sealers by a stereo and confocal laser scanning microscopy and he stated that AH plus sealer have ability to adapt to the root canal and penetrate in to the dentinal tubules.

HAND INSTRUMENTATION AND NITI ROTARY RETREATMENT

Lim VS et al²⁶ (2000) studied the effectiveness of ProFile .04 taper rotary instruments in endodontic retreatment concluded in his study that ProFile with or without chloroform seemed to be a viable alternative retreatment method for removing gutta-percha with roths sealer.

Nusair KMB³² (2002) studied gutta-percha retreatment and effectiveness of nickel-titanium rotary instruments versus stainless steel hand files and concluded that NiTi rotary and hand instrument were similar in material remaining after retreatment, but stainless steel hand file was a bit faster.

Zmener O et al⁶³ (2006) studied retreatment efficacy of hand versus automated instrumentation in oval-shaped root canals and concluded that completely clean root canal walls were not produced with any of the techniques investigated.

Gergi R et al¹⁶ (2007) stated that all instruments left filling material inside the root canal. ProTaper and R-Endo rotary instruments were inadequate for the complete removal of filling material from the root canal system.

Saad AY et al⁴⁰ (2007) studied efficacy of two rotary NiTi ProTaper and K3 instruments in the removal of gutta-percha during root canal retreatment and he

REVIEW OF LITERATURE

concluded that ProTaper and K3 were found to be effective and faster in removing gutta-percha.

Hammad M et al¹⁹ (2008) in his study teeth were scanned with a micro-Computed Tomography scan, and then root fillings were removed by using ProTaper retreatment files and hand K-files. The study showed that all tested filling materials were not completely removed during retreatment by using hand or rotary files. Gutta-percha was more efficiently removed by using hand K files.

Giuliani V et al¹⁷ (2008) concluded in his study that ProTaper retreatment files left significantly cleaner root canal walls than the K file hand instruments and the ProFile rotary instruments. Time required to remove gutta-percha is less in NiTi rotary retreatment system with respect to the Hedström files.

Tasdemir T et al⁵² (2008) studied resilon and epiphany ,guttaflow obturation system, endotwin obturation system , gutta-percha with AH Plus sealer. The filled canals were retreated by using Mtwo retreatment instruments and the mean time for retreatment of the fillings performed by using guttaflow and endotwinn methods were removed much more quickly compared with the gutta-percha with AH plus sealer.

Somma F et al⁴⁸ (2008) evaluated the effectiveness of manual and mechanical instrumentation for the retreatment of three different root canal filling materials and all instruments left remnants of filling material and debris on the root canal walls irrespective of the root filling material used. Both the engine-driven NiTi rotary systems Mtwo retreatment files and ProTaper retreatment file proved to be safe and fast devices for the removal of endodontic filling material.

REVIEW OF LITERATURE

Gu L.-S. et al¹⁸ (2008) stated in his study that ProTaper Universal rotary retreatment system removed gutta-percha more efficiently compared with other traditional techniques in maxillary anterior teeth. The better performance of ProTaper Universal retreatment instruments may be attributable to their design. D1, D2 and D3 have three progressive tapers and lengths. He also noted that the specific flute design and rotary motion of the ProTaper Universal retreatment instruments tend to pull gutta-percha into the file flutes and direct it towards the orifice. Furthermore, it is possible that the rotary movements of engine driven files produce a certain degree of frictional heat which might plasticize gutta-percha. The plasticized gutta-percha would thus present less resistance and be easier to remove penetration and removal of the softened filling material. He also concluded that no procedural errors were observed in the Hedstrom group while retreatment with rotary NiTi systems resulted in a high incidence of procedural errors

Pirani C et al³⁴ (2009) studied the effectiveness of three different retreatment techniques in canals filled with compacted gutta-percha or thermafil by Scanning Electron Microscope. Author observed that a small amount of smear layer compacted and spread only in several portions of dentin root walls was observed in all retreatment techniques and noted Ultrasound and M-Two retreatment technique created a smear layer similar to that produced by manual K files.

Betti LV et al⁵ (2009) concluded that the ProFile series 29 instruments proved to be faster than hand instruments in removing root filling materials. However, hand instruments yielded better root canal cleanliness. Some residual debris was not visualized by radiographs.

REVIEW OF LITERATURE

Huang X et al²¹ (2009) evaluated the amount of apical debris during endodontic retreatment by using the ProTaper Universal rotary retreatment system and found ProTaper retreatment file produced significantly less amount of apical extrusion than Hedstrom file resulted in cleaner canal walls in the apical third compared with the engine driven NiTi rotary systems

Unal C et al⁵⁷ (2009) compared the retreatment efficacy of hand instruments, ProFile R-Endo (MicroMega), and ProTaper Universal retreatment files in curved molar root canals and reported higher efficacy for hand instruments and ProFile NiTi instruments than ProTaper Universal retreatment file.

Bramante CM et al⁶ (2010) studied heat release, time required, and cleaning ability of Mtwo R and ProTaper universal retreatment systems in the removal of filling material and stated that none of the techniques removed the root fillings completely. Filling material removal with ProTaper retreatment file was faster but caused more heat release. Mtwo retreatment produced less heat release than the other techniques but was the least efficient in removing gutta-percha and sealer.

Dadresanfar B et al¹¹ (2011) studied efficacy of two rotary systems in removing gutta-percha and sealer from the root canal walls and concluded that Mtwo retreatment without the use of solvent was more efficient in material removal.

Lopes LDHP et al²⁷ (2011) studied torsional resistance of retreatment instruments and noted that most important parameter influencing the torsional failure of endodontic instruments is the angular deflection at failure and concluded that high angular deflection values may serve as a safety factor for retreatment instruments and

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the Mtwo retreatment instruments have the potential to exhibit a better clinical performance with regard to torsional fracture.

Shemesh H et al⁴³ (2011) studied damage to root dentin during retreatment procedures and evaluated ProTaper retreatment file and Hedstrom file and concluded that retreatment procedures result in more defects than initial treatment. When assessing the outcomes of endodontic retreatment, the substantial damage to the root canal walls should be considered.

Abramovitz et al¹ (2011) concluded in his study that the two-stage procedure using ProTaper Universal retreatment files followed by the Self adjusting file may effectively remove root canal filling material from curved canals of mandibular molars.

Rodig T et al³⁷ (2012) concluded that root canals retreated with D-RaCe instruments showed significantly less remaining filling material compared with Hedstrom files and ProTaper instruments. He also noted in his study during removal and reparation, both rotary NiTi systems removed approximately twice as much dentin as the Hedstrom files. Retreatment time in rotary retreatment system is less due to Plasticization of gutta-percha.

Solomonov M et al⁴⁷ (2012) studied self-adjusting files in retreatment by resolution Micro-Computed Tomography and concluded that the ProFile and Self adjusting file was more effective than the ProTaper R and left significantly less root filling residue in the root canal in tooth including oval shaped canal.

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Ersev H et al¹² (2012) stated that ProTaper Universal retreatment instruments were as safe and effective as hand instruments in reaching the working length. No solvent was used to prevent any interference with the removability of the sealers and its evaluation in his study. He concluded in his study that Activ GP was more effectively removed from the root canals than AH Plus with hand instrumentation.

Silva BMD et al⁴⁴ (2012) compared the effectiveness of ProTaper, D-RaCe, and Mtwo retreatment files with and without supplementary instruments in the removal of root canal filling material. He concluded that all root canals had residual filling material after retreatment even when additional instruments were used. Amongst groups in which additional instrumentation was used, the ProTaper Universal Retreatment system was the most effective system especially when compared with D-RaCe.

Mollo A et al³⁰ (2012) stated in his study that all instrumentation techniques left gutta-percha and sealer remnants inside the root canals. Ni-Ti systems were significantly faster than the manual technique and significantly more effective in removing gutta-percha particularly from the middle and apical thirds of the root canal. R-Endo instrumentation was significantly more effective than Mtwo retreatment files in removing gutta-percha from the middle and apical thirds.

Fruchi LC et al¹⁴ (2014) compare efficacy of reciprocating instruments for removing filling material in curved canals obturated with a single-cone technique using a Micro-Computed Tomographic analysis noted that Mtwo and Reciproc have an identical S-shaped cross-section with sharp cutting edges, whereas ProTaper and WaveOne have a triangular or modified triangular cross-section resulting in a smaller

REVIEW OF LITERATURE

cutting efficiency. He concluded that the use of the xylene solvent with passive ultrasonic agitation did not statistically improve the removal of the obturation material.

Topcuoglu HS et al⁵³(2014) evaluated apical crack initiation and propagation in apical dentin after use of retreatment instruments and additional instrumentation in retreatment. Finding from this study was that additional instrumentation with NiTi rotary instruments showed incidence of apical crack and propagation but the hand file group showed none. This is because both rotary instruments have an active rotating movement that may cause more friction between the files and canal walls inside the root canal and may thereby increase the incidence of cracks in which root fractures can begin to form. A further cause may be that the ProTaper (.06 taper) and Mtwo (.04 taper) instruments have a taper that is larger than hand files (.02 taper) and remove more apical dentin compared with when hand files are used. It has been stated that the more root dentin that is removed, the greater the risk of root defects.

Rodrig T et al³⁸ (2014) concluded in his study that Flexmaster NiTi rotary files were significantly faster than Hedstrom File, but were associated with a higher risk of instrument fracture. He concluded in his study that root canals retreated with Hedstromfile had significantly less remaining filling material compared with FlexMaster instrument

Rios MDA et al³⁶ (2014) concluded that the Reciproc and WaveOne reciprocating systems were as effective as the ProTaper Universal rotary retreatment system for the removal of gutta-percha and sealer from the root canal of extracted human maxillary incisors.

REVIEW OF LITERATURE

Ustun,Y et al⁵⁸ (2014) concluded in his study that NiTi systems, both with reciprocating and rotational movement caused dentinal defects during retreatment procedures. Additionally the Reciproc system was associated with significantly more cracks in the middle and coronal part of the roots than the ProTaper system.

Topcuoglu HS et al⁵³ (2014) study the apical extrusion of debris during retreatment using ProTaper, D-RaCe, and R-Endo rotary nickel titanium retreatment instruments and hand files. He concluded that the rotary NiTi retreatment systems used in his study caused less apical extrusion of debris than hand files during the removal of root canal filling material.

Keles A et al²⁴ (2015) studied the removal of filling materials from oval-shaped canals using laser irradiation by Micro-Computed Tomographic Study and noted Er:YAG laser application after the use of rotary instruments had a significantly higher removal of filling remnants. The application of lasers in retreatment procedures relies mainly on the thermal effect of irradiation which presents evidence to improve the removal of filling remnants.

Colaco AS et al⁹ (2015) compared efficiency of manual and rotary gutta-percha removal techniques and concluded that rotary techniques were more efficient than manual techniques in gutta-percha removal. Overall, the DRaCe retreatment system was most efficient, whereas manual use of H-files with System B was least efficient. However, because all the techniques showed gutta-percha remnants in the canal and radiographs failed to show these remnants, additional measures would be required to ensure complete GP removal and check for cleaner canals during endodontic retreatment.

REVIEW OF LITERATURE

Garg A et al¹⁵ (2015) concluded in his study that D-RaCe and Mtwo required significantly less time than R-Endo and hand file. Hand file took maximum time, which was significantly slower than all groups. and DRaCe removes faster than Mtwo retreatment. However, D-RaCe and Mtwo retreatment time was statistically insignificant.

Saglam BC et al⁴¹ (2015) evaluated surface alterations in different retreatment nickel-titanium files ProTaper retreatment files, R-endo files, and Mtwo retreatment files and found that all three NiTi rotary retreatment file systems showed significant deteriorations after three and five uses and noted that retreatment files always have a tendency to break off after the third time they have been used.

RETREATMENT WITHOUT SOLVENTS

Takahashi CM⁵⁰ et al (2009) studied the effectiveness of ProTaper universal rotary retreatment system for gutta-percha removal with or without a solvent and concluded that all of the techniques proved helpful for the removal of endodontic filling material, and they were similar in material remaining after retreatment but the ProTaper Universal rotary retreatment system without chloroform was faster.

Horvath et al²⁰ (2009) found that solvents led to more gutta-percha and sealer remnants on root canal walls and inside dentinal tubules. It is postulated that the softening effect of chloroform on gutta-percha results in inadvertent distribution of gutta-percha from the canal walls in the form of a film on the canal surface.

Hulsmann M et al^{AR22} (2011) stated that during removal of filling material, any further primary alteration of root canal morphology must be avoided via passive

REVIEW OF LITERATURE

instrumentation. Small amounts of a solvent may be helpful in some cases for passive removal of gutta-percha. Over-instrumentation or apical extrusion of filling material, solvent needs to be avoided

Fariniuk LF et al¹³ (2011) compared the use of nickel-titanium rotary instruments for root filling removal and root canal retreatment. An important aspect of this method is the possibility of removing the root filling material without using gutta-percha solvents. Eliminating the use of solvents may avoid the formation of a thin film of gutta-percha on the walls of the root canal. Such film might reduce the action of intracanal medicaments and the adhesion of the root canal sealer to the canal walls on the retreatment therapy. Other advantages of rotary instruments are the non-utilization of potential carcinogenic products and the elimination of possible apical extrusion of gutta-percha by excessive dissolution of this material. The frictional heat generated by rotary instruments may soften the gutta-percha and this way the working length is easily reached.

Ma J et al²⁸ (2012) found that canals filled by using the continuous wave of condensation technique had more remaining material in the apical part of the canals than those filled by using the cold lateral condensation technique. This study also noted less time was required in the non solvent groups to achieve satisfactory gutta-percha removal and root canal refinement than in the solvent groups..

Topcuoglu HS et al⁵⁴ (2014) stated in his article that solvents may alter the chemical composition of dentin surface and affect bond strength of root canal sealer to dentin.

REVIEW OF LITERATURE

Canakci BC et al⁷ (2015) studied the sealer solvent in retreatment. Resosolv (Pierre Rolland, Merignac, France) is a solvent specifically produced for resin-based sealers, such as AH Plus (DentsplyDeTrey, Konstanz, Germany). EndosolvE (Septodont, Paris, France) is a solvent specifically for eugenol based sealers, Guttasolv (Septodont) is an eucalyptol based solvent for softening gutta-percha and concluded that the amount of apically extruded debris and the duration of retreatment were reduced by the use of a solvent specific to the sealer.

SPIRAL COMPUTED TOMOGRAPHY

Nandini S et al³¹ (2006) studied the removal efficiency of calcium hydroxide intra canal medicament with two calcium chelators by volumetric analysis using Spiral CT and noted in his study that volume analysis gives a more accurate measure than surface area measurement. Using Spiral CT, three-dimensional volume measurements are possible without sectioning the specimens and thus avoiding the loss of material during sectioning.

Dall'Agnol C et al¹⁰ (2008) used Computed Tomography for assessing the removal efficiency of different techniques for removal of root canal filling material and concluded in his study that none of the techniques evaluated was effective in providing complete removal of filling material from the root canal.

Reuben J et al³⁵ (2008) stated in his study that the Spiral Computed Tomography not only helps in understanding the root canal system, but it can also give an accurate measurement for the morphology of the root canal.

REVIEW OF LITERATURE

Anbu et al² (2010) analyzed volumetric analysis of root fillings using Spiral Computed Tomography and measured the filled volume of gutta-percha with AH plus sealer in each canal using Spiral Computed Tomography and the percentage of obturated volume (POV) was calculated.

Yadav P et al⁶⁰ (2013) compared ProTaper retreatment file, Mtwo retreatment and Hedstrom files in gutta-percha removal from root canal walls using Computed Tomography and concluded in his study that Mtwo and ProTaper retreatment files left less gutta-percha and sealer than Hedstrom file. However, complete removal of filling materials was not achieved by the three systems investigated. All retreatment techniques used in this study left some filling material inside the root canal. The mean volume of remaining filling materials in the canal were less with the Mtwo retreatment. Mtwo retreatment file is efficient than ProTaper retreatment system.

Mittal N et al²⁹ (2014) used Computed Tomography for assessment of the efficacy of different rotary and hand retreatment system. Computed Tomography is non invasive method that allows visualization of morphological features in detail and does not require the destruction of the teeth and concluded that minimum time was taken by ProTaper retreatment file without solvent. This study also showed that it was difficult to remove the filling material completely when solvent was used because fine layer of softened gutta-percha adheres to the root canal wall.

MATERIALS AND METHODS

ARMAMENTARIUM (Fig no 3).

1. Micromotor straight handpiece (NSK,Japan)
2. Diamond disc (DFS Germany)
3. Endobloc (Dentsply Mailefer Switzerland)
4. K-File No 10, No15, No20 (Access, Dentsply Mailefer Switzerland)
5. Gear reduction hand piece with a torque controlled electric motor (XSmart Dentsply Maillefer Switzerland)
6. Mixing Pad and plastic spatula
7. ProTaper Universal System (Dentsply Maillefer, Ballaigues, Switzerland)
8. MTwo retreatment file (VDW, Munich, Germany)
9. DRaCe retreatment file (FKGDentaire Switzerland)
10. Hedstrom file (Mani Inc, Japan)

MATERIAL (Fig no 1, 4)

0.5% ChloramineT (SDFCL, India)

Normal saline (Baxter, India)

3% Sodium hypochlorite (Vensions India)

17% EDTA Solution (Smear off, Azure Laboratories, India)

MATERIALS AND METHODS

EDTA and Carbamideperoxide (Endoprep-RC, Anabond Stedman, India)

ProTaper paper points ((Dentsply Maillefer, Ballaigues, Switzerland)

ProTaper gutta-percha points ((Dentsply Maillefer, Ballaigues, Switzerland)

AHplus sealer (Dentsply DeTrey, Konstanz, Germany)

Cavit G(3M ESPE, St.Paul USA)

EQUIPMENTS (Fig no 10)

Spiral Computed Tomography (GE, Medical system, Canada)

MATERIALS AND METHODS

PROCEDURE

Extracted intact human mandibular premolars were collected for this study. Specimens were immersed in a 0.5% chloramine T solution ((SDFCL, India) for 48 hours for disinfection (fig no.1). They were then stored in normal saline until use. Tooth with open apex, external defects ,caries ,fractured tooth, curved root premolar are excluded and selected mandibular premolar are scanned in Spiral Computed Tomography (fig no.2) and tooth with abnormal root canal morphology, multiple root canal, large oval shaped canal, calcified canal, open apex, deviated apical foramen are excluded, thereby forty extracted intact mandibular premolars were selected for this study .The teeth were decoronated perpendicular to long axis of the root so that each root was 14 mm with a diamond disc for standardization of specimen. The working length of each canal was established with No15 K file 1mm short of the anatomical apex. Glide path created by using Kfile No10, No15, No20 . Teeth were prepared with ProTaper Universal instruments used at 300 rpm with 2 N cm of torque, up to F3 size (fig.no.3). Irrigation with 1 ml 3% sodium hypochlorite was used between each instrument and applied with a 30 gauge navitip syringe .Final rinse done with EDTA 17% for 5 minutes for smear layer removal (fig no.4). Root canals are dried with ProTaper F3 paper points and root canals were obturated with a F3 ProTaper gutta-Percha points and a AH Plus sealer (fig.no.6) by using the single cone technique(fig.no.8) and restored with Cavit G. Radiographs were taken to confirm the quality of obturation (figno.9) and teeth were stored at 37⁰C and 100% humidity for 28 days .

MATERIALS AND METHODS

The samples are numbered and the samples with the obturation material were divided in to four groups each containing 10 samples for volume analysis by three dimensional volume rendering linux software using Spiral CT (fig.no.11) and to receive one of the four retreatment protocols,

Groups	Method and specification	Manufacturer
I (Fig no 13)	ProTaper Retreatment Files (D1D2, and D3) D1-ISO size 30,taper 0.09.Length16mm D2-ISOsized 25 taper 0.08 length -18mm D3-ISOsized 20,taper 0.07 ,length-22mm	(Dentsply Maillefer Switzerland)
II (Fig no 14)	Mtwo R1 ISO size 25 taper 0.05 length -21mm. Mtwo R2 ISO size 15 taper 0.05, length-21mm	(VDW, Munich, Germany)
III (Fig no 15)	D-RaCe retreatment File DR1(ISO size 30, 0.10 taper length 15mm- 8mm active tip DR2 (ISO size 25, 0.04 taper Length -25mm-16mm safety tip	(FKG Dentaire Switzerland)
IV (Fig No.16)	Hedstrom File- ISO size 15-30	(Mani Inc, Japan)

MATERIALS AND METHODS

Retreatment

All rotary NiTi instruments were used with a torque and speed-controlled motor (X-Smart, Dentsply Maillefer) at the torque and speed recommended by the manufacturer for each specific system used. Root fillings were removed using the following techniques

GROUP I-(PROTAPER RETREATMENT FILE)

ProTaper R instruments (fig no.13) were used with a constant speed of 500 rpm, as suggested by the manufacturer. The instruments were used with a brushing action against the canal walls in a crown-down direction until the working length was reached. D1 was used to remove the filling from the coronal third of the root. D2 was used to remove the filling from the middle third of the root. D3 was used to remove the filling from the apical third of the root.

GROUP II- (MTWO RETREATMENT FILE)

Mtwo R1 25/0.05 with a constant speed of 280rpm and torque of 1.2Ncm was used to retreat the coronal and middle thirds of the root. Mtwo R215/0.05 with torque of .3Ncm was used to reach the working length. Use Mtwo Retreatment file (fig.no14) without downward pressure. Gradually remove the root canal filling with circumferential filing movements.

GROUP-III (DRACE RETREATMENT FILE)

Canal fillings were removed using the D-RaCe retreatment instruments (fig no.15) as follows: DR1 (size 30, 0.10 taper) at a speed of 800 rpm and a torque of 1.5

MATERIALS AND METHODS

Ncm for the cervical third and beginning of the middle third and DR2 (size 25, 0.04 taper) at a speed of 600 rpm and a torque of 1 Ncm to the working length. The DR2 instrument was used with light apical pressure until the working length was reached.

GROUP IV (HAND INSTRUMENT HEDSTROM FILE)

Canals were reinstrumented with Hedstrom files (mani), sizes 30, 25, 20, and 15 (fig.no.16) in a circumferential, quarter-turn, push-pull, filing motion to remove filling material until the working length was achieved. Retreatment was judged complete when no gutta-percha or sealer was detected on the instrument surfaces.

The time needed for the procedure was measured with a stop watch for each sample.

EVALUATION:

Canal Wall Cleanliness:

A second Spiral CT (fig.no18) was done for all the specimens and the volume of remaining material in each root canal was estimated as before (fig.no.19). The removal efficiency was calculated using the formula

$$\{(a-b) \times 100 / a\}$$

where **a** was the volume of material obturated in the root canal and

b was the volume remaining in the root canal after retrieval

MATERIALS AND METHODS

Total time for retreatment:

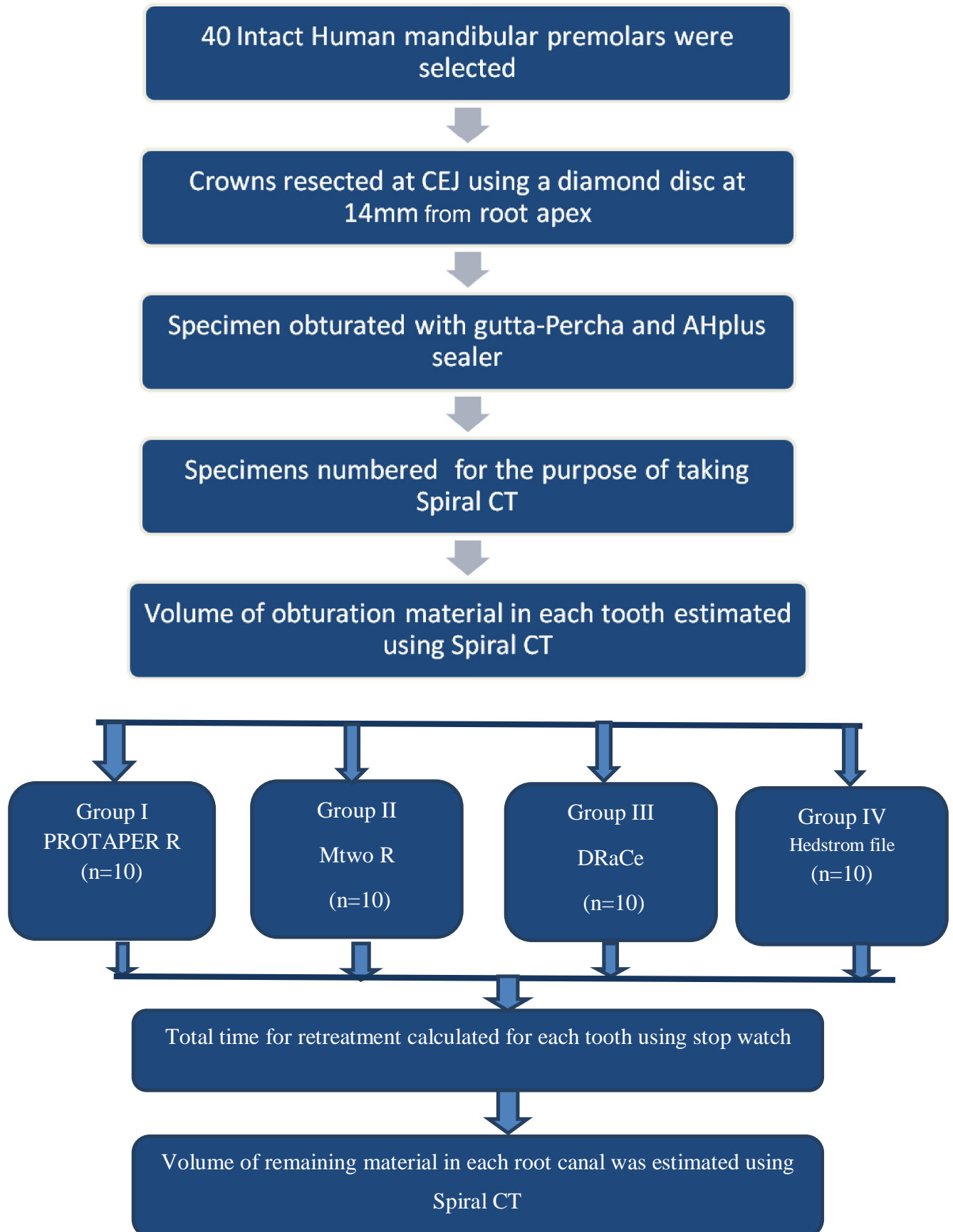
The time required for reaching the working length and for removal of Gutta-percha obturated with epoxy resin sealer (AH Plus; Dentsply, Germany) until the completion of retreatment were noted

The following results were obtained from our study and were tabulated:

- Volume of the obturated material
- Volume of the remaining obturated material
- Time taken for retrieval of the obturated material by stop watch

The results were tabulated and the data were then subjected to statistical analysis using SPSS version 16 software.

MATERIALS AND METHODS



MATERIAL AND METHODS

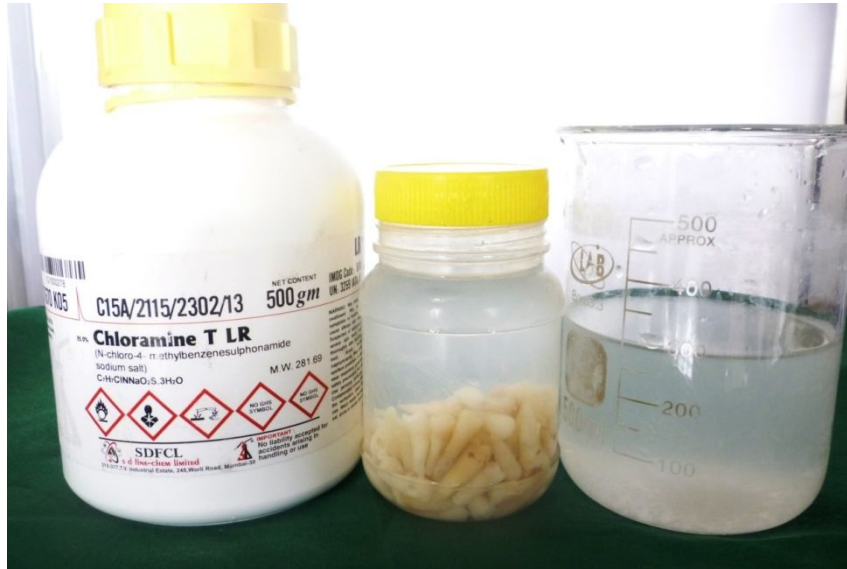


Fig No.1 Extracted Mandibular Premolar

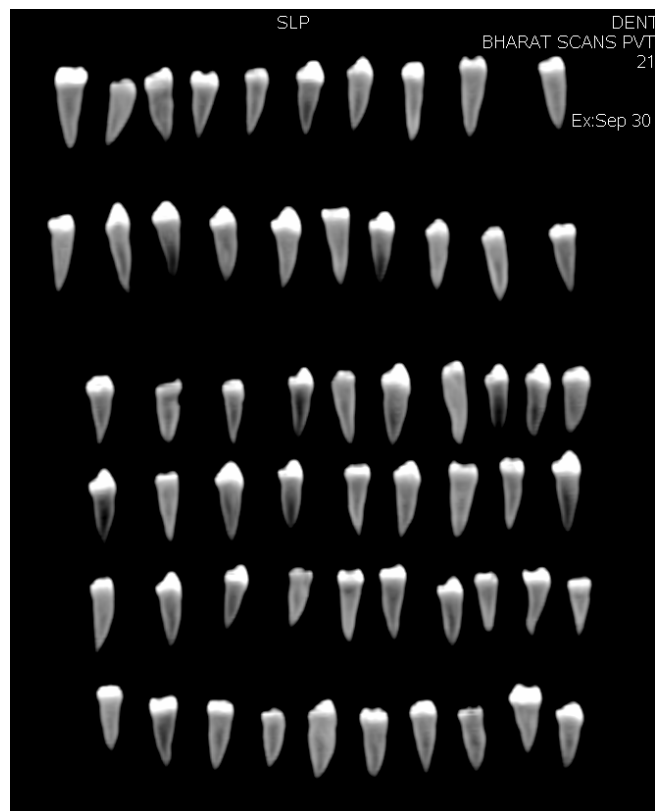


Fig No.2 Spiral Computed Tomography Scan for tooth selection.

MATERIAL AND METHODS



Fig No.3 Armamentarium.



Fig No.4 Irrigants.

MATERIAL AND METHODS



Fig No.5 Restorative Material



Fig No.6 ProTaper Gutta-Percha with AH Plus Sealer

MATERIAL AND METHODS



Fig No.7 Mixing of AH Plus Sealer



**Fig No.8 Obturation with ProTaper
guttapercha Point**

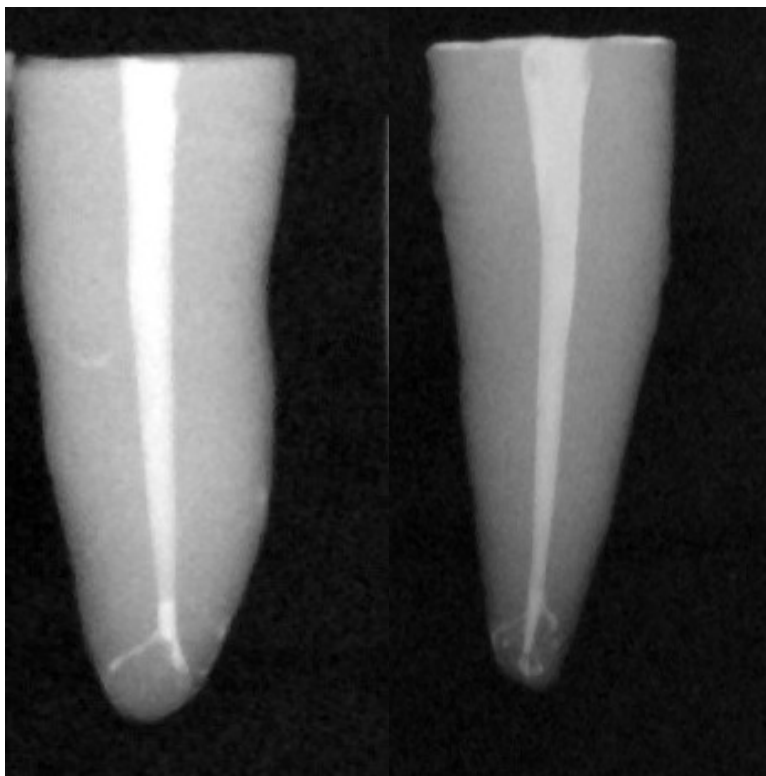


Fig No.9 Radiovisiographic image of obturated canal

MATERIAL AND METHODS



Fig No.10 Spiral Computed Tomography Scan

MATERIAL AND METHODS



Fig No.13 ProTaper retreatment file



Fig No.14 MTwo retreatment file

MATERIAL AND METHODS



Fig No.15 DRaCe retreatment file



Fig No.16 Hedstrom file



Fig No.17 Retreatment file with gutta-percha

MATERIAL AND METHODS



Fig No.18 CT image after retreatment

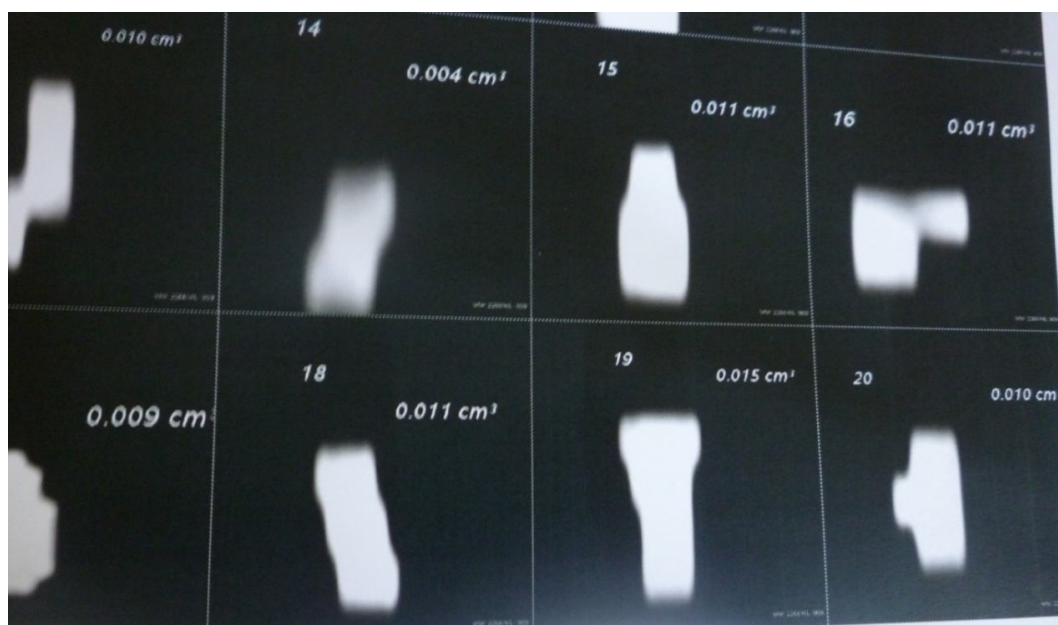


Fig No.19 Volume analysis after retreatment

RESULTS

Statistical analysis:

Data obtained in the present study was assessed for normality using *Shapiro Wilks test for normality of data* and the data was found to be parametric in distribution.

The following statistical tests were carried out in our study:

- *One way ANOVA* for comparison of mean difference between the four groups.
- *Tukeys Post Hoc Test* for pairwise comparison between the groups.

pvalue of ≤ 0.05 was used to determine significance.

The data obtained were tabulated and analysed using SPSS software version 16.

- The volume of material obturated in canal for the four groups in cm^3 is shown in Table. 1
- The volume of the material in the canal after retreatment for the four groups is represented in Table. 2.
- The removal efficiency of the 4 groups in percentage were tabulated in Table 3.
- Mean and standard deviation of the removal efficiency of the four groups are shown in Table 4
- The results of the one way ANOVA comparing the percentage removal efficiency among the four groups is represented in Table 5.
- The individual comparison of the four groups with Tukey Post hoc test is shown in Table 6

RESULTS

- The time taken for removal of obturating materials is shown in Table 7.
- Mean and standard deviation of the time taken for retreatment for the four groups are shown in Table 8.
- The results of the one way ANOVA comparing the time taken for retreatment for the four groups are shown in Table 9.
- The Multiple comparisons of the time taken for retreatment for the 4 groups using Tukey Post hoc test is tabulated in table 10

Table 1 : VOLUME OF MATERIAL OBTURATED IN CANAL in cm³

Sample No.	GROUP I	GROUP II	GROUP III	GROUP IV
1	0.07	0.022	0.061	0.043
2	0.06	0.068	0.026	0.069
3	0.056	0.087	0.04	0.061
4	0.072	0.046	0.055	0.053
5	0.074	0.041	0.039	0.044
6	0.054	0.039	0.04	0.08
7	0.057	0.042	0.077	0.068
8	0.041	0.045	0.053	0.062
9	0.053	0.048	0.062	0.078
10	0.051	0.061	0.085	0.081
MEAN	0.0588	0.0499	0.0538	0.0639

RESULTS

Table 2 : VOLUME OF MATERIAL IN CANAL AFTER RETREATMENT in cm³

Sample No.	GROUP I	GROUP II	GROUP III	GROUP IV
1	0.008	0.019	0.008	0.006
2	0.003	0.017	0.005	0.038
3	0.003	0.01	0.008	0.018
4	0.017	0.004	0.003	0.003
5	0.03	0.011	0.006	0.016
6	0.02	0.011	0.006	0.044
7	0.005	0.009	0.004	0.035
8	0.015	0.011	0.011	0.017
9	0.018	0.015	0.011	0.017
10	0.02	0.01	0.025	0.015
MEAN	0.01	0.01	0.008	0.021

RESULTS

Table 3 : REMOVAL EFFICIENCY (Values in Percentage)

Sample No.	GROUP I	GROUP II	GROUP III	GROUP IV
1	88.57	76.8	86.88	86.04
2	95	80.68	80.76	44.92
3	94.64	88.5	80	70.49
4	76.38	91.3	94.54	94.33
5	59.45	73.17	84.61	63.63
6	62.96	71.79	85	45
7	91.22	78.57	94.8	48.52
8	63.4	75.55	79.24	72.58
9	66.03	77.94	82.25	78.2
10	60.7	83.6	70	81.48
7MEAN	75.835	79.79	83.808	68.519

RESULTS

Table 4 : MEAN AND STANDARD DEVIATION OF THE CALCULATED REMOVAL EFFICIENCY (PERCENTAGE) OF THE 4 GROUPS

Canal Wall Cleanliness

	N	Mean	Std. Deviation
Protaper	10	75.8350	15.03392
M2	10	79.7900	6.35352
Drace	10	83.8080	7.34278
H file	10	68.5190	17.60428
Total	40	76.9880	13.34559

Table 5 : ONE WAY ANOVA OF REMOVAL EFFICIENCY OF THE 4 GROUPS

ANOVA

Canal Wall Cleanliness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1274.170	3	424.723	2.696	.060
Within Groups	5671.920	36	157.553		
Total	6946.090	39			

RESULTS

Table 6 : PAIRWISE COMPARISON OF THE REMOVAL EFFICIENCY OF THE FOUR GROUPS

Tukey HSD

Canal Wall Cleanliness

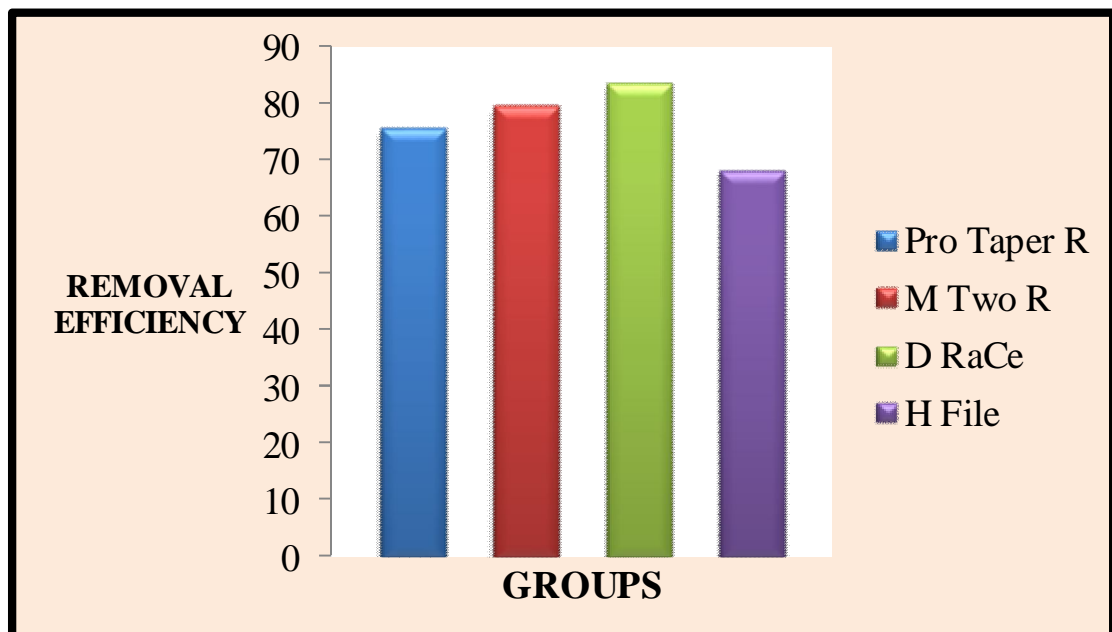
(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
Protaper	M2	-3.95500	5.61344	.895
	Drace	-7.97300	5.61344	.495
	H file	7.31600	5.61344	.567
M2	Protaper	3.95500	5.61344	.895
	Drace	-4.01800	5.61344	.890
	H file	11.27100	5.61344	.204
Drace	Protaper	7.97300	5.61344	.495
	M2	4.01800	5.61344	.890
	H file	15.28900*	5.61344	.047
H file	Protaper	-7.31600	5.61344	.567
	M2	-11.27100	5.61344	.204
	Drace	-15.28900*	5.61344	.047

*. The mean difference is significant at the 0.05 level.

RESULTS

GRAPH 1

COMPARISON OF PERCENTAGE OF FILLING MATERIAL RETRIEVED



RESULTS

Table 7 : TIME IN MINUTES FOR RETREATMENT FOR THE 4 GROUPS

Sample No.	GROUP I	GROUP II	GROUP III	GROUP IV
1	7.43	5	6.2	13.36
2	8.25	6.5	5.3	12
3	9.3	4	5.2	11.5
4	8.23	5.2	5	13.5
5	8.3	6.27	5	10.5
6	7	6.3	5.2	9
7	7	6	6	10.5
8	8	6	6.5	11
9	7.5	6.3	5.5	10.2
10	8	6.2	5.8	11.2
MEAN	7.901	5.777	5.57	11.276

RESULTS

Table 8 : MEAN AND STANDARD DEVIATION OF THE TIME TAKEN FOR RETREATMENT FOR 4 GROUPS

Parameter		N	Mean	Std. Deviation
Timeinminutes	Protaper	10	7.9010	.69700
	M2	10	5.7770	.79482
	Drace	10	5.5700	.52715
	H file	10	11.2760	1.39395
	Total	40	7.6310	2.48321

Table 9 : ONE WAY ANOVA OF THE TIME TAKEN FOR RETREATMENT FOR 4 GROUPS

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Timeinminutes	Between Groups	210.440	3	70.147	84.045	.000
	Within Groups	30.047	36	.835		
	Total	240.486	39			

RESULTS

Table : 10 MULTIPLE COMPARISONS OF THE TIME TAKEN FOR RETREATMENT FOR THE 4 GROUPS USING TUKEY POST HOC TEST

Tukey HSD

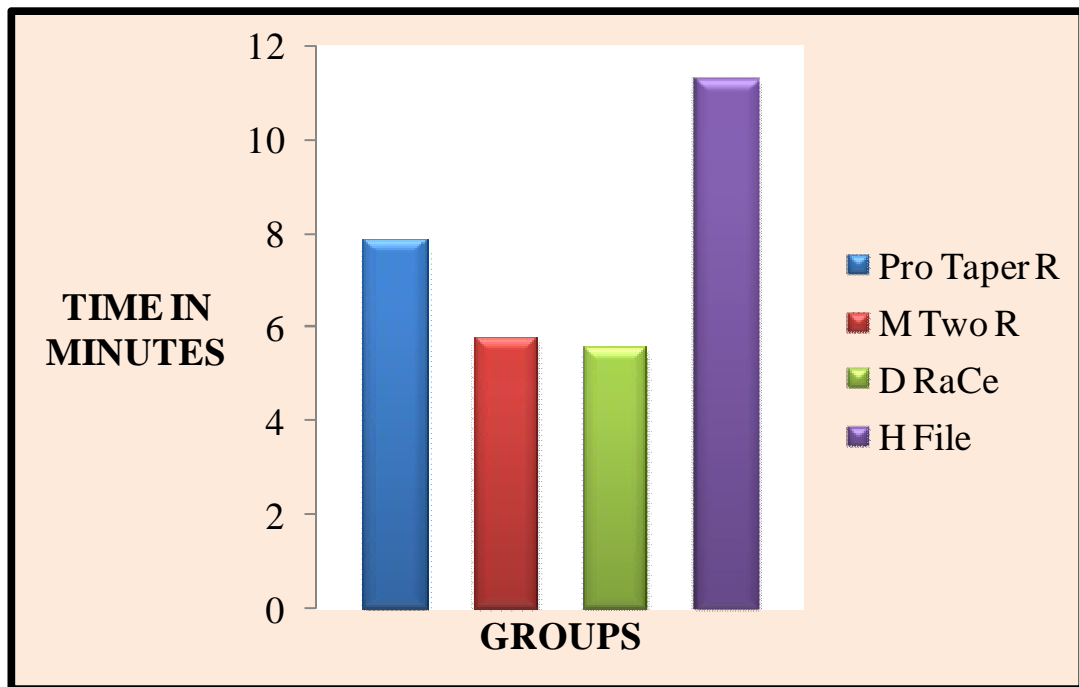
Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
Timeinminutes	Protaper	M2	2.12400 [*]	.40857	.000
		Drace	2.33100 [*]	.40857	.000
		H file	-3.37500 [*]	.40857	.000
	M2	Protaper	-2.12400 [*]	.40857	.000
		Drace	.20700	.40857	.957
		H file	-5.49900 [*]	.40857	.000
	Drace	Protaper	-2.33100 [*]	.40857	.000
		M2	-.20700	.40857	.957
		H file	-5.70600 [*]	.40857	.000
	H file	Protaper	3.37500 [*]	.40857	.000
		M2	5.49900 [*]	.40857	.000
		Drace	5.70600 [*]	.40857	.000

*. The mean difference is significant at the 0.05 level.

RESULTS

GRAPH 2

COMPARISON OF TOTAL TIME FOR RETRIEVAL FOR FOUR GROUPS



RESULTS

Result interpretation

Removal efficiency:

Intergroup comparison:

With respect to removal efficiency it was observed that DRaCe group had the highest mean removal efficiency (83.84 ± 7.34) followed by M Two R (79.79 ± 6.35), Pro Taper R (75.83 ± 15.03). Group III \geq Group II \geq Group I $>$ Group IV (Graph 1). Least mean removal efficiency was observed among H files (68.52 ± 17.60). However this difference was not found to be statistically significant ($p=0.06$).

Pairwise comparison:

Pair wise comparison with Tukey's Post Hoc test revealed that that there was a significant mean difference between DRaCe and H files groups. ($p=0.04$)

Time duration:

Intergroup:

With respect to total time for retreatment, it was observed that the lowest mean time taken for retreatment was by DRaCe group(5.5m)followed by M Two R (5.7m), Pro Taper R (7.9m) (Graph 2). Highest mean total time for retreatment was observed among H files (11.2m). This difference was found to be Statistically significant. ($p=0.0001$).

RESULTS

Pairwise comparison:

On Pair wise comparison it was noted that although all groups showed significant mean difference ($p=0.0001$) in the total time for retreatment, Group II and Group III did not exhibit any statistically significant mean difference ($p=0.957$)

DISCUSSION

Treatment options for the retention of endodontically treated teeth with post treatment disease are limited. They included non surgical retreatment, surgical treatment (including intentional replantation), or a combination of both procedures. Torabinejad M et al ⁵⁶2009 reported that non surgical retreatment showed a higher rate of success (83.0%) compared with endodontic surgery (71.8%) at each recall visit. These findings suggest nonsurgical retreatment offers a more favorable long-term outcome and should be considered as a primary treatment approach when possible compared with endodontic surgery.

Nonsurgical endodontic retreatment is often indicated as the first choice to eliminate or reduce microbial infection when initial root canal treatment fails⁸. The retreatment aims to completely remove the filling material from the canal system to allow effective cleaning, shaping, and filling of the root canal. It is important to remove as much obturating materials as possible during retreatment to uncover remnants of necrotic tissue or microorganisms that might be responsible for endodontic failure.⁴⁶

Gutta-percha in conjunction with sealers is the most common root filling material.³⁰ AH Plus is a epoxy resin based sealer used in our study which has strong sealing ability due to great adhesion to dentin and consequent reduced bacterial leakage.⁶²

Several techniques have been proposed to remove filling materials from the root canal system, including the use of endodontic hand files, (K-type or Hedstrom files) and engine-driven instruments (eg, ultrasonic files, Gates-Glidden and rotary

DISCUSSION

nickel-titanium instruments) and other methods like heat, ultrasonic instruments, lasers and solvent.

Solvent was not used in this study with the purpose to eliminate a possible confounding factor. Solvents are potentially harmful. Softened root filling material by solvents could be pushed further into the irregularities along the root canal walls and dentinal tubules, making its removal more difficult.²⁰ NiTi rotary system can be used for removing gutta-percha without solvents. Use of solvents can form a thin film of gutta-percha on the wall of root canal and it can reduce the action of intracanal medicament.¹³

It has been shown that the use of rotary nickel-titanium (NiTi) instruments for the removal of root fillings during retreatment is safer.⁷¹ Rotary techniques are faster because of the motion, inherent speed, greater taper, flute design and active tip of the rotary files. Rotary files in motion generate frictional heat, which plasticizes and softens gutta-percha. The rotary instruments convey debris toward the cervical portion of the canal because of their cross-sectional shape¹⁸ and it is possible to remove gutta-percha and AHplus sealer without solvent.

Newer NiTi rotary system specially designed for retreatment are developed such as ProTaper retreatment file, Mtwo retreatment file, DRaCe retreatment file, and reciprocating NiTi file (R-Endo). Very few studies are there to compare and evaluate the efficiency of newer retreatment file and very limited study is there to compare ProTaper retreatment file, Mtwo retreatment file, DRaCe retreatment file and hand instrument Hedstrom file without solvent. So in our study we evaluate the effect of newer NiTi retreatment file system such as

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ProTaper retreatment file, Mtwo retreatment file, DRaCe retreatment file. and compared with Hedstrom file without solvent by Computed Tomography.

Evaluation of the effectiveness of removal and identification of remnants of the filling material under clinical conditions is difficult. In experimental studies, this can be monitored by splitting the root and examining the two halves under a microscope. In research, Computed Tomography, micro-CT, Scanning Electron Microscopy, Clearing techniques, and stereomicroscopy have also been used for identification of remnants of filling material and root canal cleanliness. We used Computed Tomography analysis in our study. It can provide three dimensional volume analysis with precisely outlining filling material by a dedicated software. It is non invasive and volume in cm^3 can be calculated before and after retreatment.

All instruments should be used in specific speed and low torque for maximum efficiency. The low-torque hand piece approved to increase tactile sensitivity, give better control of rotary instrumentation, and reduced the risk of instrument separation. This study uses gear reduction hand piece driven by electric motor where speed and torque can be controlled may contribute to better efficiency. If we use low speed than recommended by manufacturer does not results in efficient removal of obturating material.

ProTaper Universal retreatment instruments were used at a constant speed of 500 rpm for D1, D2 and D3 with a torque of 3 Ncm. The speed and torque were established by previous analyses and followed manufacturer's recommendations. D1 ISO size 30 taper 0.09 was used to remove obturating material from coronal part of root canal, D2 ISO size 25 taper 0.08, to remove obturating material from middle

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part of root canal and D3-ISOsize 20, taper 0.07 used to remove obturating material from apical part of root canal.

Ma J et al²⁸ (2012) concluded in his study ProTaper retreatment file leaves less residual filling when it is used without solvent, mean percentage is 6.04% than ProTaper with solvent and supplemental instrumentation with ProTaper finishing file was done in this study.

In our study, it is observed that ProTaper retreatment file can reach working length without solvent but leaves more residual filling than other rotary files because it is not supplemented by additional instrumentation.

Giuliani V et al¹⁷ (2008) stated that ProTaper Universal retreatment system performed better than Hedstrom files and also observed that ProTaper retreatment file require less time with respect to Hedstrom file which is in accordance with our study.

T. Rodig et al³⁸ (2014) concluded that root canals retreated with Hedstrom File had significantly less remaining filling material compared with FlexMaster instrument, it is not in accordance with our study. The reason could be previous study used solvent with Hedstrom file. But in our study, H file is used without solvent. To standardize last apical size of Hedstrom file used in our study is No 30 may be reason for more residual filling.

In our study it is noted that gutta-percha with epoxy resin based sealer is difficult to remove with Hedstrom file from canal wall and it leaves more residual filling and time consuming .Newer retreatment files system provides better cleaning

DISCUSSION

ability than Hedstrom file. Retreatment instruments have specially designed for retreatment purpose with flute design, active cutting tip for initial instrument penetration and rotary files in motion generate frictional heat, which plasticizes and softens gutta-percha makes retreatment faster than Hedstrom file.

Mtwo retreatment file consists of Mtwo R1 and Mtwo R2. Both instruments have an S shaped cross section. Mtwo retreatment has active tip for all retreatment instruments and a constant helical angle.

Bramante CM et al⁶ (2010) compared Mtwo retreatment file and ProTaper retreatment file without solvent and found that ProTaper retreatment file was better than Mtwo retreatment file since ProTaper R leaves lesser filling residue. Mtwo retreatment is better than ProTaper retreatment in our study.

Dadresanfar B et al¹¹ (2011) studied Efficacy of two rotary systems in removing gutta-percha and sealer from the root canal wall and concluded that Mtwo R without the use of solvent was more efficient in material removal compared to ProTaper retreatment file which is in accordance with our study.

Yadav P et al⁶⁰ (2013) concluded in his study, that the mean volume of remaining filling materials in the canal were less with the Mtwo retreatment and ProTaper rotary retreatment systems compared to hand instruments and Mtwo retreatment file is efficient than ProTaper retreatment system which is also in accordance with our study.

The DRaCe rotary system consists of 2 files DR1 and DR2 especially designed for retreatment. DR1 is a 15mm in length, size 30 file with a cutting tip,

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10% tapering capable of 1/3 coronal cleaning. DR2 is a 25mm in length, size 25 file with 4% tapering for 2/3 apical cleaning.

Rodig T et al³⁷(2012) concluded in his study that DRaCe instruments were associated with significantly less residual filling material than ProTaper Universal Retreatment instruments and Hedstrom file, No difference was found between ProTaper retreatment and Hedstrom file in removal of gutta percha. Our study also revealed that DRaCe is more efficient in removing obturating material than ProTaper retreatment, Mtwo retreatment but statistically not significant.

This finding may be attributed to the alternating cutting edges that prevent the screw effect, favoring penetration in to the filling material.²⁴ The flute area of these instruments allows coronal extrusion of filling material and the smooth instrument surface created by a special electrochemical treatment, which might also contribute to the superior sharpness of these instruments.^{11,20}

Colaco AS and Pai VAR⁹ (2015) concluded in their study that DRaCe is better than ProTaper retreatment file and Hedstrom file which is in accordance with our study. Contrary to this study **Silva BMD et al**⁴⁴ (2012) studied the effectiveness of ProTaper, DRaCe, and Mtwo retreatment files with and without supplementary instruments in the removal of root canal filling material. They stated in their study that DRaCe is less efficient when it is used alone without supplementation than Mtwo retreatment file.

So far none of the retreatment techniques used in previous studies have been able to completely remove traces of gutta-percha/sealer from the root canal.⁵⁵

DISCUSSION

All groups after retreatment demonstrated some residual filling material on the canal wall in this study. The apical diameters of ProTaper D3 instrument ISO size 20, MtwoR2 instrument ISO size 25, DRaCe DR2 ISO size 25 respectively. These retreatment instruments, which are designed to reach the working length, may not provide complete removal of root canal filling material from the apical third⁷. The purpose of study is to find efficiency of retreatment file so additional instrumentation not used in this study. Additional measures such as the supplemental instrumentation with combination of rotary and manual techniques and newer research are recommended to enhance the removal of gutta-percha during endodontic retreatment.

It is observed from the study that epoxy resin sealer is not completely removed from canal wall which is in accordance with study **Wilcox LR et al**⁵⁹ (1987), reason may be there is no chemical attachment between gutta-percha and epoxy resin based sealer. There is more tendency for sealer to remain inside the canal wall, so to enhance complete removal of sealer newer techniques are required.

In our study, no instrument fracture was observed in NiTi rotary retreatment file during the root canal filling removal procedure. Possibly due to straight canal without curvature used in our study and manufacturers recommendation followed regarding speed and torque. But studies reported that NiTi retreatment file fractured in curved canal. Rotary NiTi instrument plasticizes gutta-percha and active cutting tip penetrates easily, hence there was no evidence of fracture with rotary files. In our study one instrument fracture occurred in Hedstrom file. Hedstrom file difficult to penetrate as rotary NiTi file when solvents are not used. Precaution should be taken to avoid force during retreatment while using Hedstrom file.

DISCUSSION

Time

The engine driven rotary NiTi file required less time for retreatment than Hedstrom files. This is probably caused by the gutta-percha plasticization resulting from rotation of the instrument⁴. In the present study all types of rotary NiTi instruments were significantly faster than hand files in removing gutta-percha, while DRaCe and Mtwo retreatment file instrument systems required less time than ProTaper retreatment file.

Garg A et al ¹⁵ (2015) concluded in his study that DRaCe and Mtwo required significantly less time than R-Endo and hand file. Hand file took maximum time, which was significantly slower than all groups and DRace removes faster than Mtwo retreatment. However DRaCe and Mtwo retreatment time was statistically insignificant.

Rotary retreatment techniques were more efficient than manual techniques in gutta-percha removal. Among these techniques, the rotary DRaCe retreatment system was most efficient, whereas the manual use of H-files was least efficient in our study. Removal efficiency between DRaCe, Mtwo retreatment, and ProTaper are not statistically significant.

Assessment of debris extrusion are not done in this study since it is major criteria for success of retreatment is the limitation of this study, but noted by observer that NiTi retreatment cause less extrusion of debris .Maintenance of correct working length is required to prevent extrusion of debris. Another limitation was invitro study do not simulate clinical condition where access, morphology of tooth varies. All root

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canals had residual filling material after retreatment. To conclude additional instrumentation is required to enhance cleaning efficiency during retreatment. Gutta-percha with epoxy resin based sealer can be removed from canal without solvent by rotary NiTi file and removal with Hedstrom file is tedious and time consuming.

SUMMARY

Forty extracted human mandibular premolar were selected and used for this study. Crowns were resected at the cemento enamel junction using a diamond disc. 40 specimens were randomly divided in to four group of 10 teeth. Teeth were prepared with ProTaper Universal instruments up to F3 size and root canals were obturated with a F3 ProTaper gutta-percha points and a AH Plus sealer by using the single cone technique. Each specimen is mounted for the purpose of taking Spiral CT. Volume of obturation material in each tooth was estimated using Spiral CT. Each group received one of the four treatment protocols.

Group I -ProTaper retreatment file,

Group II-Mtwo retreatment file,

Group III-D-RaCe retreatment file,

Group IV-Hedstrom file

Time for reaching working length and total time for complete retrieval of the material were calculated for each tooth. A second Spiral CT was taken for all the specimen and the volume of remaining material in each root canal was estimated by three dimensional volume rendering Linux software and removal efficiency was calculated. Data were analyzed statistically. DRaCe group had the highest mean removal efficiency (83.84 ± 7.34) followed by M Two R (79.79 ± 6.35), Pro Taper R (75.83 ± 15.03). Least mean removal efficiency was observed among H files (68.52 ± 17.60). Group III \geq Group II \geq Group I $>$ Group IV. However this difference was not found to be statistically significant among rotary retreatment files ($p=0.06$). All root canals had residual filling material after retreatment. Additional instrumentation is

SUMMARY

required to enhance cleaning efficiency during retreatment. Gutta-percha with epoxy resin based sealer can be removed from canal without solvent by rotary NiTi file and removal with Hedstrom file is tedious and time consuming.

The working time required for complete retrieval of obturated material from the root canal was significantly longer for Hedstrom file compared to Rotary Niti retreatment file.

Among the mechanical NiTi rotary retreatment files used in our study, DRaCe required less duration for retrieval comparing to Mtwo and ProTaper retreatment files and the difference is statistically not significant.

CONCLUSION

Within the limitation of this study following conclusion were drawn.

- Mechanical rotary NiTi retreatment systems are more efficient than manual instrumentation.
- DRaCe is more efficient in removing gutta-percha and epoxy resin based sealer in comparison to Mtwo retreatment file and ProTaper retreatment file but difference is not statistically significant.
- Manual hand instrument using Hedstrom file without solvent is the least efficient in removing obturation material and the difference with D-Race being statistically significant.
- The working time required for retrieval of obturated material from the root canal was significantly longer for Hedstrom file compared to Rotary Niti retreatment file.
- Among the mechanical NiTi rotary retreatment files used in our study, DRaCe requires less duration for retrieval comparing to Mtwo and ProTaper retreatment files and the difference is statistically not significant.

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